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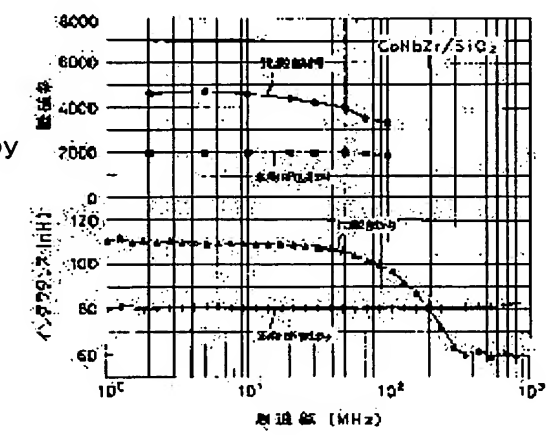
(71)Applicant : AMORPHOUS DENSHI DEVICE KENKYUSHO:KK
(72)Inventor : SUGAWARA HIDEKUNI
MATSUMOTO FUMIO
FUJIMORI HIROYASU
MASUMOTO TAKESHI

(54) AMORPHOUS SOFT MAGNETIC THIN FILM AND MANUFACTURE THEREOF

(57)Abstract:
PURPOSE: To provide a method of manufacturing an amorphous soft magnetic multilayered thin film very excellent in high frequency characteristics of permeability or inductance and bias-resistant magnetic characteristics.
CONSTITUTION: Amorphous magnetic layers and insulating layers are alternately laminated to form a multilayered film, where the magnetic layers are made to shift from each other by a certain angle in an easy magnetization direction.



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CLAIMS

[Claim(s)]
[Claim 1] The amorphous soft magnetism multilayered film characterized by shifting the easy magnetization direction of each magnetic layer the degree of arbitration angle within a film surface for every membrane formation of a magnetic layer in the amorphous soft magnetism multilayered film to which the laminating of an amorphous magnetic layer and the insulating layer was carried out by turns.
[Claim 2] The manufacture approach of the amorphous soft magnetism multilayered film characterized by the easy magnetization direction of each magnetic layer shifting and giving an include angle within a film surface for every membrane formation of a magnetic layer in the manufacture approach of the amorphous soft magnetism multilayered film which produces the multilayers to which the laminating of an amorphous magnetic layer and the insulating layer was carried out by turns.

[Translation done.]

DETAILED DESCRIPTION

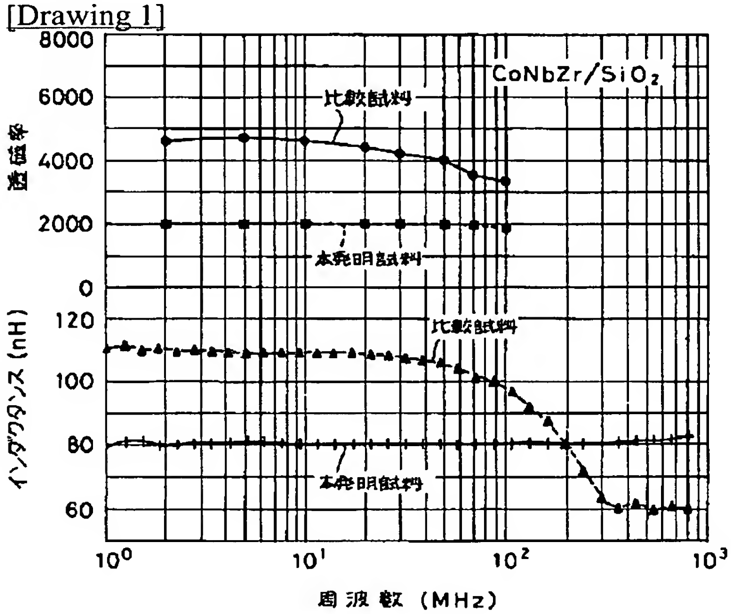
[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the amorphous soft magnetism multilayered film used for core ingredients used in a high frequency band, such as an inductor and a transformer, and its manufacture approach.
[0002]
[Description of the Prior Art] In recent years, the inductor of high frequency band use and the request of a transformer increase from a viewpoint of the miniaturization of electronic equipment, and high-performance-izing, and an ingredient with the soft magnetic characteristics which were excellent in the RF region also as a core ingredient in connection with this is desired. The ferrite, the amorphous alloy, etc. have been used as such soft magnetic materials for cores.
[0003]
[Problem(s) to be Solved by the Invention] When using in a high frequency band, thin film-ization of an ingredient can be considered inevitably. Although specific resistance rho of a ferrite is very high, its saturation magnetic flux density Bs is low, and Spinel structure still more nearly required for soft magnetism in a thin film is not formed. On the other hand, since it is large a single figure compared with a crystalline substance alloy although an amorphous alloy compares and is inferior to a ferrite in specific resistance rho, and saturation magnetic flux density Bs is quite larger than a ferrite, it is suitable for thin film-ization.
[0004] When forming the core thin film used in a high frequency band using this amorphous alloy, membrane formation among a 1 shaft field is usually performed, and it considers as multilayers with the uniaxial magnetic anisotropy which carried out the laminating of a nonmagnetic insulating layer still like the ceramics to the magnetic layer by turns. It is a general approach in case a field is added in the direction of a hard axis and high frequency band application uses these multilayers for it. Although the property was usually maintained by this to the resonance frequency, it was not what is not necessarily satisfied.
[0005] This invention was made in view of the above-mentioned situation, and aims at providing the high frequency property list of permeability or an inductance with the extremely excellent amorphous soft magnetism multilayered film and its manufacture approach of bias-proof magnetic influence.
[0006]
[Means for Solving the Problem] It is characterized by for the easy magnetization direction of each magnetic layer shifting an include angle within a film surface for every membrane formation of a magnetic layer, and giving it, in case this invention produces the multilayers to which the laminating of an amorphous magnetic layer and the insulating layer was carried out by turns, in order to solve the above-mentioned technical problem.
[0007]
[Function] This invention is the amorphous soft magnetism multilayered film which whose natural resonance frequency is very high, for example, was excellent as a core of the high frequency band use exceeding 100MHz with the above-mentioned means.
[0008] That is, in case this invention produces the multilayers to which the laminating of an amorphous magnetic layer and the insulating layer was carried out by turns, it can obtain the amorphous soft magnetism multilayered film which excelled [list / of permeability mu or an inductance L / high frequency property] the easy magnetization direction of each magnetic layer in bias-proof magnetic influence extremely by shifting and giving an include angle within a film surface, and forming membranes for every membrane formation of a magnetic layer.
[0009]

[Example] With reference to a drawing, the example of this invention is explained to a detail below.
[0010] Although the multilayered film of this invention carries out the laminating of the insulating layers, such as an amorphous alloy magnetic layer, an oxide, or a nitride, by turns and is produced by the spatter etc., there is especially no limitation of a presentation of an amorphous alloy etc., it has soft magnetic characteristics excellent in the RF field, and high saturation magnetic flux density, the magnetostriction near zero, and the ingredient that has high electrical-and-electric-equipment specific resistance further are suitable. It will not limit, especially if it is within the limits usually used about the thickness of an insulating layer. A magnetic layer surely forms membranes in a 1 shaft field in order to give uniaxial magnetic anisotropy at the time of the membrane formation. The description of this invention is in the laminating conditions of this magnetic layer. That is, it is an indispensable condition that the magnetic layer of the bottom immediately after the easy magnetization direction of each magnetic layer sandwiches an insulating layer is shifted the degree of arbitration angle within a film surface. The multilayered film core acquired by the approach of such this invention is extremely excellent in the identity nature of the permeability mu or an inductance L to the field near GHz. The concrete example of this invention is shown below.
Membrane formation production of the multilayered film was carried out the following condition using the concrete example-1 RF sputtering system.
target :magnetic-substance: -- Co86Nb9 Zr5 (atomic %)
insulator: -- SiO2 spatter condition: -- controlled atmosphere: -- Ar substrate side field: -- 80Oe thickness : CoNbZr:0.25micrometer/layer SiO2 : 0.17-micrometer [/layer] laminating period : 4 (they could be four layers each)
Laminating conditions : The easy magnetization direction of the 1st magnetic layer is made into 0 degree. easy magnetization direction [of the 2nd magnetic layer]: -- the 1st layer -- receiving -- easy magnetization direction [of the +45 degree 3rd magnetic layer]: -- the 1st layer -- receiving -- easy magnetization direction [of the +90 degree 4th magnetic layer]: -- to the 1st layer, -45 degrees, at the time of magnetic layer membrane formation, grant of the easy magnetization direction shifted the direction of a substrate side field suitably, and, in addition, performed it each time.
[0011] For the comparison, uniaxial-magnetic-anisotropy multilayers were completely produced on the same conditions with this invention except laminating conditions. Permeability mu and inductance L measurement were performed by the sample of a width-of-face [of 10mm] x die-length a dimension of 10mm. The excitation field was impressed to the right angle in the easy magnetization direction of a comparison sample. The result is shown in drawing 1 .
[0012] That is, although, as for a comparison sample, permeability mu and an inductance L show a high value in a low frequency region, the frequency stability was clearly inferior compared with this invention sample, balking began from linearity above about 20MHz, and the rapid fall has arisen. On the other hand, this invention sample is made into permeability mu, about about 2000 are maintained, the identity nature is maintained to 500-600MHz, and it turns out that it is a sample with the very high stability over a frequency.
Concrete example -2 [0013] In the thin film list of this invention sample produced on the same conditions as the concrete example -1, about the uniaxial anisotropy sample thin film of a comparison sample, the direct-current field (Hdc) was added to the measured thin film S as shown at drawing 3 to 10Oe(s) in the direction of a right angle at the high-frequency field (f= 10MHz), and the effect to a bias field was seen.
[0014] The result is shown in drawing 2 . When A1 adds a field in the direction of an easy axis (Easy axis) in the case of a comparison sample and A2 adds a field in the direction of a hard axis (Hardaxis), A3 of drawing 2 (a) is the case of a null (blank). As for drawing 2 (b), when B1 adds a field in the easy magnetization direction (Easy direction) in the case of this invention sample and B-2 adds a field in the difficult magnetization direction (Hard direction), B3 is the case of a null (blank). That is, as for this invention sample, it is clear as drawing 2 that it is stable to the external magnetic field (bias field Hdc) of Number Oe.
[0015]
[Effect of the Invention] As stated above, in case the multilayers to which the laminating of an amorphous magnetic layer and the insulating layer was carried out by turns are produced according to this invention, the effectiveness which is understood that the amorphous soft magnetism multilayered film which excelled [list / of permeability or an inductance / high frequency property] in bias-proof magnetic influence extremely is obtained, and is exerted on this industrial meaning and the industrial world is large by shifting an include angle and giving the easy magnetization direction of each magnetic layer within a film surface, for every membrane formation of a magnetic layer.

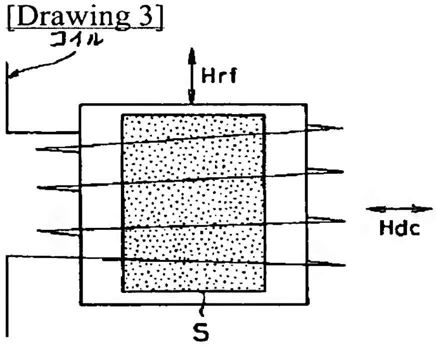
- [Translation done.]

DRAWINGS

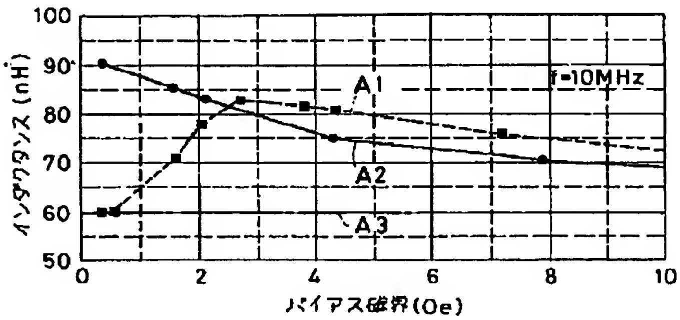
[Drawing 1]



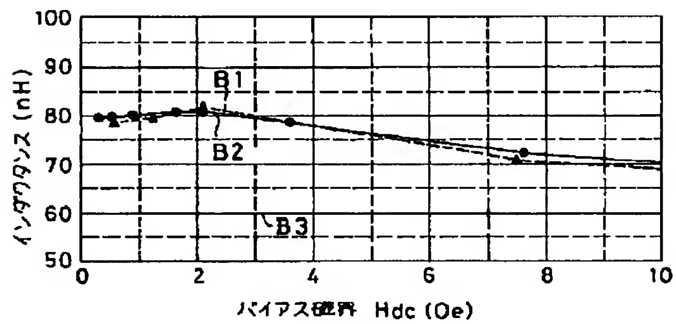
[Drawing 3]



[Drawing 2]



(a)



(b)

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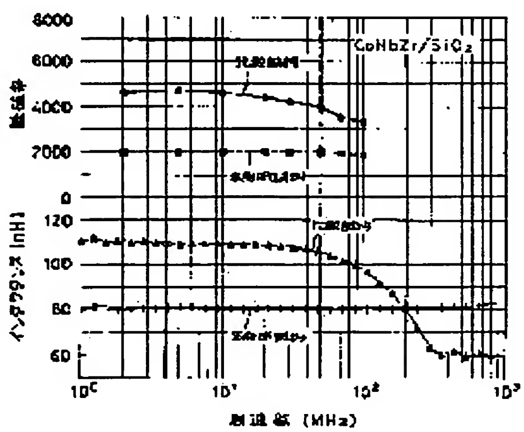

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審査請求　未請求　請求項の数2(全 4 頁)　最終頁に続く

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(71)出願人　000126942
株式会社アモルフアス・電子デバイス研究所
宮城県仙台市青葉区南吉成6丁目6番地の3

(72)発明者　菅原　英州
宮城県仙台市青葉区芋沢字権現森山112番地の1　株式会社アモルフアス・電子デバイス研究所内

(74)代理人　弁理士　鈴江　武彦

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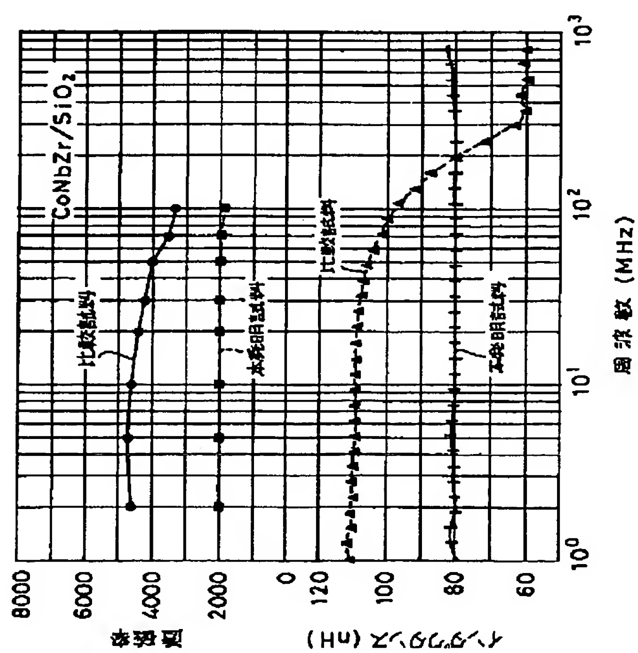
(54)【発明の名称】　非晶質軟磁性多層薄膜及びその製造方法

(57)【要約】

【目的】本発明は、透磁率或いはインダクタンスの高周波特性並びに耐バイアス磁界特性の極めて優れた非晶質軟磁性多層薄膜及びその製造方法を提供することを目的とする。

【構成】本発明は、非晶質磁性層と絶縁層を交互に積層させた多層膜を作製する際に、各磁性層の容易磁化方向が磁性層の成膜ごとに膜面内で角度をずらして付与されることを特徴とするものである。



【特許請求の範囲】

【請求項１】　非晶質磁性層と絶縁層を交互に積層させた非晶質軟磁性多層薄膜において、各磁性層の容易磁化方向が磁性層の成膜ごとに膜面内で任意角度ずれていることを特徴とする非晶質軟磁性多層薄膜。

【請求項２】　非晶質磁性層と絶縁層を交互に積層させた多層膜を作製する非晶質軟磁性多層薄膜の製造方法において、各磁性層の容易磁化方向が磁性層の成膜ごとに膜面内で角度をずらして付与することを特徴とする非晶質軟磁性多層薄膜の製造方法。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は高周波帯域で使用されるインダクタ、トランスなどの磁心材料に用いられる非晶質軟磁性多層薄膜及びその製造方法に関するものである。

【０００２】

【従来の技術】近年、電子機器の小型化、高性能化の観点から高周波帯域使用のインダクタ、トランスの要請が高まり、これに伴って磁心材料としても高周波域で優れた軟磁気特性を持つ材料が望まれている。この様な磁心用軟磁性材料としてはフェライト、非晶質合金などが用いられてきた。

【０００３】

【発明が解決しようとする課題】高周波帯域で用いる場合、必然的に材料の薄膜化が考えられる。フェライトは比抵抗ρが極めて高いが飽和磁束密度Ｂｓが低く、さらに薄膜では軟磁性に必要なスピネル構造が成膜されていない。一方、非晶質合金は比抵抗ρがフェライトに比し劣るものの結晶質合金に比べ一桁大きく、飽和磁束密度Ｂｓがフェライトよりかなり大きいので、薄膜化には適している。

【０００４】この非晶質合金を用い高周波帯域で使用する磁心薄膜を成膜する場合、通常は一軸磁界中成膜を行い、更にセラミックスのような非磁性絶縁層を磁性層と交互に積層した一軸磁気異方性をもつ多層膜とする。かかる多層膜を磁化困難軸方向に磁界を加えて用いるのが高周波帯域適用の場合の一般の方法である。これによって通常は共鳴周波数まで特性が保たれるが必ずしも満足するものではなかった。

【０００５】本発明は上記の事情に鑑みてなされたもので、透磁率或いはインダクタンスの高周波特性並びに耐バイアス磁界特性の極めて優れた非晶質軟磁性多層薄膜及びその製造方法を提供することを目的とする。

【０００６】

【課題を解決するための手段】本発明は上記課題を解決するために、非晶質磁性層と絶縁層を交互に積層させた多層膜を作製する際に、各磁性層の容易磁化方向が磁性層の成膜ごとに膜面内で角度をずらして付与されることを特徴とするものである。

【０００７】

【作用】本発明は上記手段により、自然共鳴周波数の極めて高い、例えば１００ＭＨｚを越える高周波帯域使用の磁心として優れた非晶質軟磁性多層薄膜である。

【０００８】即ち、本発明は非晶質磁性層と絶縁層を交互に積層させた多層膜を作製する際に、各磁性層の容易磁化方向を磁性層の成膜ごとに膜面内で角度をずらして付与し成膜する事によって、透磁率μ或いはインダクタンスＬの高周波特性並びに耐バイアス磁界特性の極めて優れた非晶質軟磁性多層薄膜を得ることができる。

【０００９】

【実施例】以下図面を参照して本発明の実施例を詳細に説明する。

【００１０】本発明の多層薄膜はスパッタ法等によって非晶質合金磁性層と酸化物或いは窒化物等の絶縁層を交互に積層して作製されるが、非晶質合金の組成等の限定は特にはなく、高周波領域で優れた軟磁気特性を有し高飽和磁束密度、ゼロに近い磁歪、更に高電気比抵抗を持つ材料が適している。絶縁層の厚みに関しては通常用いられる範囲内であれば特に限定するものではない。磁性層はその成膜時に一軸磁気異方性を付与するため、必ず一軸磁界中にて成膜する。本発明の特徴はこの磁性層の積層条件にある。即ち、それぞれの磁性層の容易磁化方向が絶縁層を挟んだすぐ上或いは下の磁性層とは膜面内で任意角度ずれていることが必須条件である。この様な本発明の方法によって得た多層薄膜磁心はＧＨｚに近い領域までその透磁率μ或いはインダクタンスＬの恒等性が極めて優れる。以下に本発明の具体的実施例を示す。

具体的実施例－１

高周波スパッタ装置を用い次の条件で多層薄膜を成膜作製した。

ターゲット　：磁性体：$Co_{86}Nb_{9}Zr_{5}$　（原子％）

絶縁体：SiO_2

スパッタ条件：雰囲気ガス：Ａｒ

基板面磁界：８０Ｏｅ

膜厚　：ＣｏＮｂＺｒ：0.25μｍ／層

SiO_2　　：0.17μｍ／層

積層周期　：４（各４層とした）

積層条件　　：第１磁性層の容易磁化方向を０°とする。

第２磁性層の容易磁化方向：第１層に対し＋４５°

第３磁性層の容易磁化方向：第１層に対し＋９０°

第４磁性層の容易磁化方向：第１層に対し－４５°

尚、容易磁化方向の付与は磁性層成膜時にその都度基板面磁界方向を適宜ずらして行った。

【００１１】比較のために、積層条件以外は本発明と全く同一条件で一軸磁気異方性多層膜を作製した。透磁率μ及びインダクタンスＬ測定は幅１０ｍｍ×長さ１０ｍｍ寸法の試料で行った。励磁磁界は比較試料の容易磁化方向に直角に印加した。その結果を図１に示す。

【0012】即ち、比較試料は低周波域では透磁率μ、インダクタンスLともに高い値を示すが、明らかにその周波数安定性が本発明試料に比べ劣り、ほぼ20MHz以上で直線性から離脱が始まり急激低下が生じている。これに対し、本発明試料は透磁率μにしてほぼ2000程度を保ちその恒等性が500～600MHzまで維持されており、周波数に対する安定性が極めて高い試料であることが判る。具体的実施例－2

【0013】具体的実施例－1と同一条件で作製した本発明試料の薄膜並びに比較試料の一軸異方性試料薄膜について、図3に示すような被測定薄膜Sに、高周波磁界（f＝10MHz）に直角方向に直流磁界（Hdc）を10Oeまで加え、バイアス磁界に対する影響を見た。

【0014】その結果を図2に示す。図2（a）は比較試料の場合で、A1は磁化容易軸（Easy axis）方向に磁界を加えた場合、A2は磁化困難軸（Hardaxis）方向に磁界を加えた場合、A3は空白（blank）の場合である。図2（b）は本発明試料の場合で、B1は容易磁化方向（Easy direction）に磁界を加えた場合、B2は困難磁化方向（Hard direction）に磁界を加えた場合、B3は空白（blank）の場合である。即ち、図2のとおり、本発明試料は数Oeの外部磁界（バイアス磁界Hdc）に対し安定していることが明白である。

【0015】

【発明の効果】以上述べたように本発明によれば、非晶質磁性層と絶縁層を交互に積層させた多層膜を作製する際に、各磁性層の容易磁化方向を磁性層の成膜ごとに膜面内で角度をずらして付与することにより透磁率或いはインダクタンスの高周波特性並びに耐バイアス磁界特性の極めて優れた非晶質軟磁性多層薄膜が得られることが判り、この工業的意義、産業界に及ぼす効果は大きい。

【図面の簡単な説明】

【図1】本発明試料に関わる非晶質軟磁性多層薄膜と、比較試料として通常の一軸磁気異方性非晶質多層磁性薄膜の透磁率並びにインダクタンスの周波数依存の一例を示す特性図である。

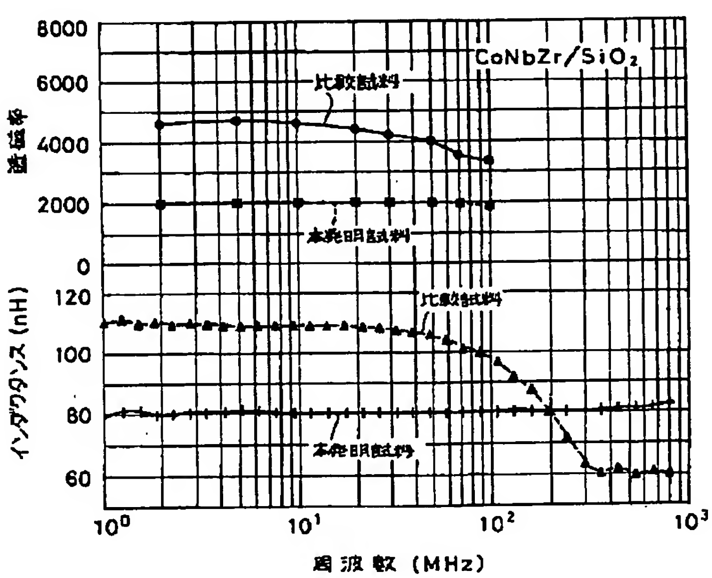
【図2】本発明試料に関わる非晶質軟磁性多層薄膜と比較して通常の一軸磁気異方性非晶質多層磁性薄膜のバイアス磁界特性の一例を示す特性図である。

【図3】本発明に係る被測定薄膜と磁界との関係の一例を示す説明図である。

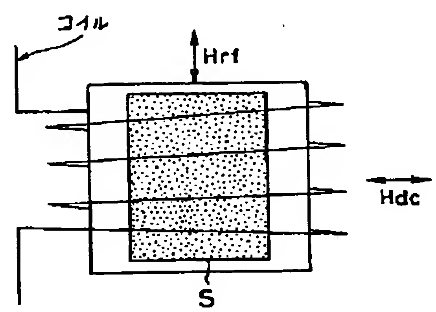
【符号の説明】

S…被測定薄膜。

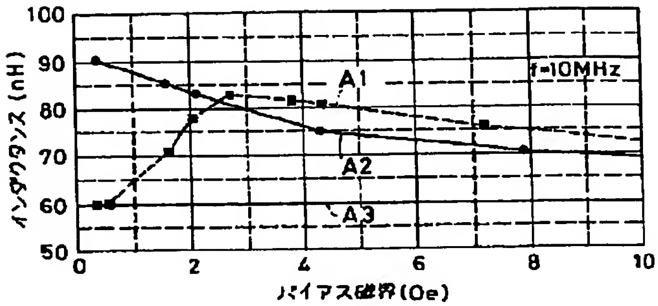
【図1】



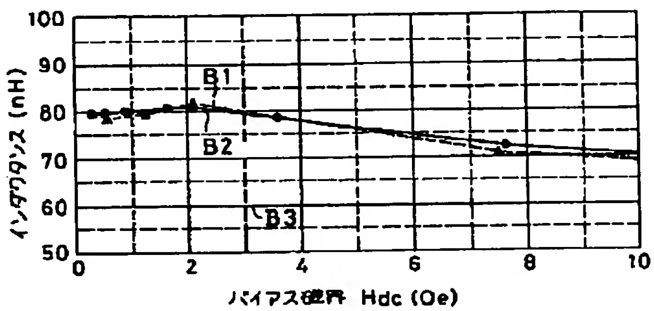
【図3】



【図２】



(a)



(b)

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(72)発明者　松本　文夫
宮城県仙台市青葉区芋沢字権現森山112番地の１　株式会社アモルフアス・電子デバイス研究所内

(72)発明者　藤森　啓安
宮城県仙台市青葉区吉成２－20－３

(72)発明者　増本　健
宮城県仙台市上杉３－８－22